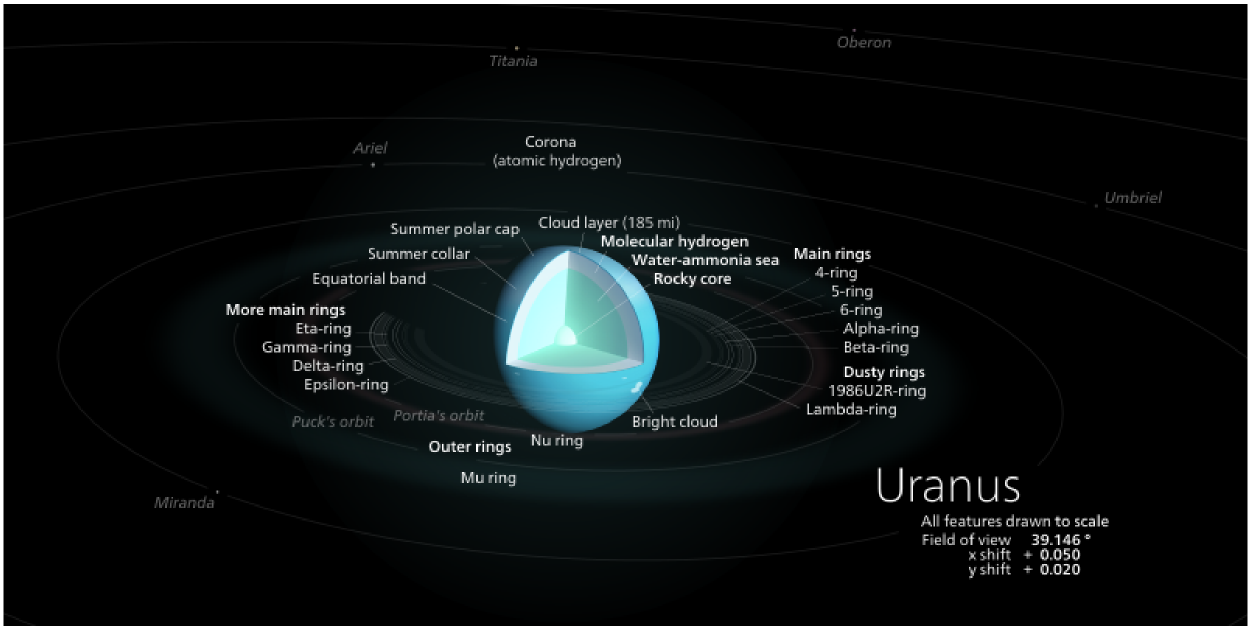
11.4: Uranus and Neptune

The two largest Jovian planets were known to ancient people. In contrast, the **ice giant**s, Uranus and Neptune were only discovered in recent centuries. Uranus was discovered by William Herschel in 1781 as he was surveying the sky with a telescope he made himself. Neptune was discovered in 1846 using mathematical observations of Uranus' orbit which indicated it was being influenced by the gravity of a fourth Jovian world. Three men worked independently to calculate Neptune's orbit and locate it: Johann Gottfried Galle, Urbain Jean Joseph Le Verrier, and John Couch Adams. There is dispute over who discovered it first, so Neptune has no single official discoverer. Le Verrier, in France, worked out the mathematics of where Uranus could be found and asked Galle in Germany to look for it. Using coordinates supplied by LeVerrier, Galle quickly spotted the Uranus. However, the English astronomer Adams also claimed to have spotted Uranus before Galle, so the three have had to share credit for its discovery.

Because they are smaller than Jupiter and Saturn, both Uranus and Neptune have lower internal pressures. These pressures are not extreme enough to convert hydrogen into metallic hydrogen. Both planets vast oceans of liquid molecular ammonia, methane, and hydrogen extend from the base of the atmosphere down to what may be ice/rock core. These oceans are at very high pressure, and they reach temperatures of several thousand Kelvin.

Uranus and Neptune differ in composition compared to Jupiter and Saturn. Both have a higher proportion of silicates, metals, and impurities.

11.5.1 Uranus



Uranus and its interior.

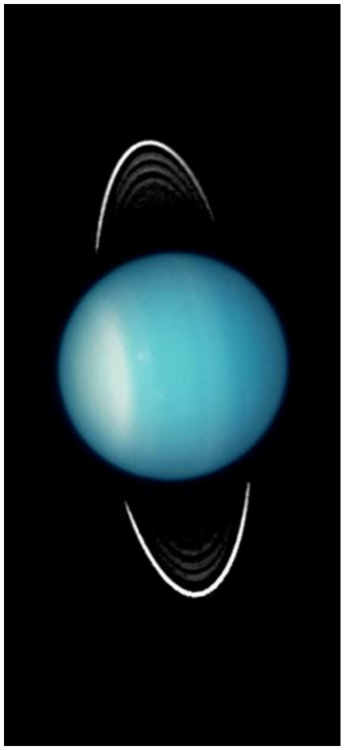
https://commons.wikimedia.org/wiki/F...us_diagram.svg

Uranus is best known for its unusual axial tilt. Its axis of rotation lies almost in the plane of its orbit. This gives Uranus extreme seasonal variations. Astronomers have been able to measure its rotation by watching storms.

Uranus has an atmosphere composition as follows:

- 83 ± 3% Hydrogen (H_2)
- 15 ± 3% Helium
- 2.3% Methane
- 0.009% Hydrogen
- (0.007–0.015%) deuteride (HD)
- Ices in Uranus’ atmosphere include: Ammonia, water, ammonium, hydrosulfide (NH_4SH), methane (CH_4).

The high concentrations of ices such as methane give it a bluish green color. Methane absorbs red light. Also, the same scattering of blue light that exists in Earth's atmosphere also occurs in Uranus. These two factors work together to give Uranus its distinctive color. The blue color is less prominent for Jupiter and Saturn because their uppermost clouds have less methane haze above them.



Uranus with its rings, showing its unusual axial tilt.

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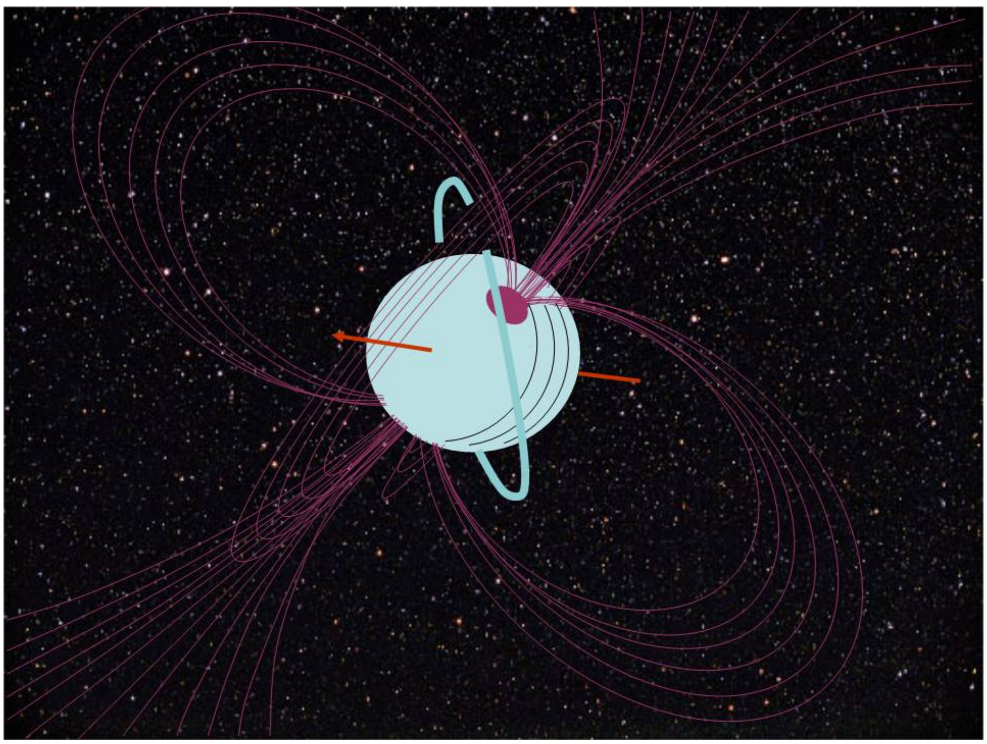

Magnetic field of Uranus.

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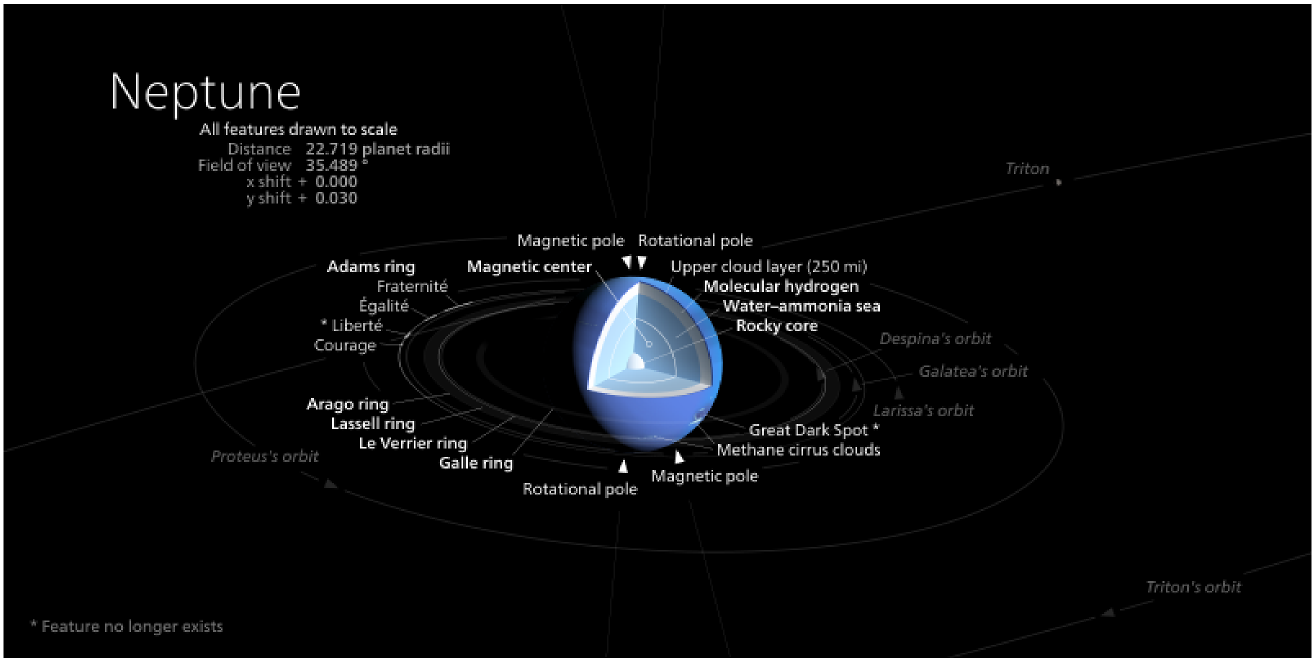
The atmospheres of Uranus and Neptune are still less active than Jupiter and Saturn and both planets lack the obvious bands of convective motion. Uranus' clouds indistinct because they are hidden beneath a thick layer of haze. This makes the planet appear almost featureless.

Beneath the troposphere, Uranus' layers include a layer of molecular hydrogen followed by a layer of "slush" consisting of water, methane, and hydrogen. Below the slush layer may be a rocky core.

Uranus has a substantial magnetic field, but the axis of is magnetic field is oddly off-center and tilted 60 degrees from its axis of rotation. In contrast, Earth's magnetic field axis is tilted by 11 degrees from its axis of rotation.

Uranus: radiates 1.06 times the energy it receives from the Sun. Like Jupiter, is it believed that this is excess energy from its formation as the planet contracted.

11.5.2 Neptune



Neptune and its interior

https://commons.wikimedia.org/wiki/F...ne_diagram.svg

Neptune has storm systems like those on Jupiter, but fewer.

Neptune’s atmosphere composition is as follows:

- 80±3.2% Hydrogen (H_2)
- 19±3.2% Helium
- 1.5±0.5% Methane
- ~0.019% Hydrogen deuteride (HD)
- ~0.00015% Ethane.
- Ices on Neptune include ammonia, Water, Ammonium hydrosulfide(NH_4SH), Methane (CH_4).

The layers below the troposphere on Neptune are about the same as those on Neptune: Molecular hydrogen, followed by a “slush” layer of water, methane, and hydrogen, and then a rocky core.

Neptune also has strangely tilted magnetic field that is angled at 46 degrees from the axis of rotation.

Neptune emits nearly 2.6 times as much energy as it receives, but the source of that energy is not well understood. Two different situations are possible: either Neptune suffered a great many collisions with comets and other debris early in its life or it is actually raining diamonds on Neptune. In the first scenario, these materials that Neptune absorbed are currently undergoing gravitational contraction and has these former comets comprise, they're radiating heat. Alternatively, according to work done by Raymond Jeanloz and Laura Benedetti, liquid methane in Neptune's atmosphere may be condensing into diamonds, or at least diamond dust, and as this material falls through Neptune's atmosphere it is causing frictional heating much like the liquid helium on Saturn.

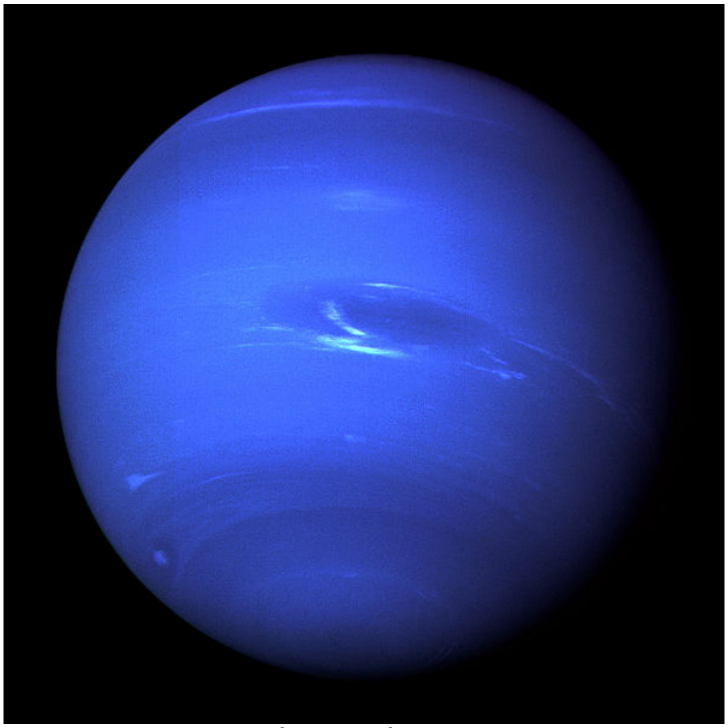


Image of Neptune from Voyage 2

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Unlike Uranus, Neptune has an atmosphere in which convection currents, vertical drafts of gas, rise from the interior and fall back down These currents are powered by the planet’s internal heat source. The currents carry warm gas above the 1.5-bar cloud level, forming additional clouds at elevations about 75 kilometers higher. Despite Neptune’s smaller size and different cloud composition, Voyager showed that it had an atmospheric feature much like Jupiter’s Great Red Spot. Called Neptune’s Great Dark Spot, this storm was measured at nearly 10,000 kilometers long. Like Jupiter, giant storms formed at latitude 20° S, had the same shape, and took up about the same fraction of the planet’s diameter. Data from Voyager 2 found the Great Dark Spot rotated with a period of 17 days, versus about 6 days for the Great Red Spot. However, when the Hubble Space Telescope examined Neptune in the mid-1990s, astronomers could find no trace of the Great Dark Spot on their images. It appears that the Great Dark Spot has faded away.

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